COAST DEFENCE.

I would call your attention to the subject of coast defence and in as brief a manner as possible touch upon certain points which may, as it were, serve as texts to you in pursuing your studies upon this most neglected but important subject. We have as you all know (not including Alaska) about 4000 miles of sea coast, presenting every feature of coast and water.

In May 1885, a board were appointed by the President of the United States, under the provision of an act of Congress to examine and report at what ports fortifications or other defences are most urgently needed, the character and kind of defences best adapted for each, with reference to armament and the utilization of torpedoes, mines and other defensive appliances. The report of the Board made in January 1886 is full of facts and figures and, bearing in mind the advances made in armor, guns and torpedoes, this report can be studied to-day with benefit. After taking us on an inspecting tour from Calais, Maine, to the northwestern boundary and around our lake frontier, and pointing out the lines of rail communications adjacent to the coast, the board find that defences are most necessary at the following ports, arranged in order of urgency:

1. New York.
2. San Francisco.
3. Boston.
4. The Lake ports.
5. Hampton Roads.
6. New Orleans.
7. Philadelphia.
8. Washington.
9. Baltimore.
10. Portland, Maine.
11. Rhode Island ports in Narraganset Bay.
12. Key West.
13. Charleston, S. C.
14. Mobile.

15. New London.
16. Savannah, Ga.
17. Galveston.
18. Portland, Oregon.
19. Pensacola, Fla.
20. Wilmington, N. C.
21. San Diego Cal.
22. Portsmouth, N. H.
23. Defences of Cumberland Sound at Fort Clinch.
24. Defences of ports of the Kennebec River, Maine, at Fort Popham.
25. New Bedford, Mass.
26. Defences of ports on the Penobscot River, Maine, at Fort Knox.
27. New Haven, Conn.

numbering as we see 27.

The Board further, in stating at what ports fortifications or other defences are most urgently needed, presents the following list:

1. New York.
2. San Francisco.
3. Boston.
4. The Lake ports.
5. Hampton Roads.
6. New Orleans.
7. Philadelphia.
8. Washington.
9. Baltimore.
10. Portland, Maine.
11. Rhode Island ports in Narraganset Bay.

eleven in all.

The Board also specified the character, armament and other accessories of defence.

The report, as I said, was made in January 1886, and a casual glance at the defences of these ports, as things exist this day will show how little has been accomplished in carrying out the recommendations of the board after a lapse of eight years. This failure

is due in no measure to the lack of professional knowledge or energy in the officers whose province it is to construct and arm, but must be attribtued entirely to the absence of necessary appropriations.

It may be urged, that, when this report was made, we had no navy, such as we now possess, and therefore it is not necessary to fortify to as great an extent. I can only say, in answer to this, that every first-class power in addition to constructing most powerful naval vessels, has been continuously strengthening its sea-coast fortifications.

A study of our coast lines will show many points or harbors, which, whilst not being commercial ports in the full sense of the word, and which on account of their not containing public and private wealth, and of the absence thereat of navy yards or depôts of military stores, would not offer tempting marks, still would be most valuable as furnishing a base contiguous to a portion of the country to be operated on and also as a harbor of refuge and repair. We might mention as coming into this category, Eastport, Calais and several other bays on the coast of Maine; Provincetown harbor, Cape Cod Bay, Gardiner's Bay; sea board entrances to inland navigation, Delaware Bay, Chesapeake Bay, and along Carolina and southern coast; Port Royal Roads, Key West, Tampa Bay, and Saint Joseph's Bay.

On Pacific coast, San Pedro and Santa Monica Bays; Monterey Bay; Port Angeles in the straits of Juan de Fuca, and New Dungennes Bay, Protection Island, Port Townsend and Puget Sound, and many others, for no one of which has any system of defence, as far as we know, been provided.

The whole question of coast defence is, as it were, in the air, or rather in the realm of uncertainty, owing to the fact that modern ships and modern guns have come so little into actual hostility with modern shore works and guns; and again in the few cases where modern ships have assailed shore batteries of the old types with a few modern guns, the results have in no measure approximated to those formulated after exhaustive experiments carried out under peace conditions.

In the very start I wish to disclaim any intention of ignoring the

importance of the Navy in all coast defences and I would just here quote from from Captain Mahan, whose facile pen expresses in a much clearer manner than I can, my feelings upon this point.

"A wisely co-ordinated system of defences does not contemplate that every part is to hold out indefinately but only for such a time as may be necessary for it to receive the support which the other parts of the whole are intended to supply. That the navy is the first line of defence both in order and in importance, by no means implies that there is or should be no other.

This forced and extravagant interpretation, for which naval officers have been largely responsible, of the true opinion that the navy is the best protection for a sea frontier, has had much to do with the faulty strategy, which would tie the fleet, whatever its power to the home ports and disseminate it amongst them. Navies do not dispense with fortifications nor with armies, but, when wisely handled they may serve their country. The strain which comes, when these have to be called into play, when war once remote thunders at the gates and the sea the mother of prosperity is shut off."

It is claimed first, that no fleet will attack a thoroughly fortified harbor. Granted, provided the advantage to be gained, be it what it may, is not commensurate with the risks, but the instant that this advantage exists from any cause whatever, an attack of some description will be made. But even supposing that no attack by reason of the strength of the fortifications be made, is this any argument against fortifications. Is it not in fact a point altogether in their favor, as enabling them without firing a shot to afford protection to ship, dockyard, naval station, and treasures, etc., of every description. I do not suppose the most radical of the opponents of fortifications would argue, if all ship supplies, dockyards, naval stations, etc., existed without protection of fortifications, that they would be safe from attack.

Again it is claimed by an officer high in the naval service abroad, that no fleet will attack a defended harbor within 700 miles of a fleet of that power, and as an example in support of that assertion is quoted the failure of Vice-Admiral Bouët-Willaumez to bombard the coast town of Colberg in the Baltic Sea, though he had, at least

as far as Germany was concerned, the command of the sea, the failure being laid to the fact of the presence in the Jahde of an inferior German fleet. The facts in this case, as far as I have been able to make out, are as follows:

The German fleet in the Jahde consisted of three ironclads and one monitor of comparatively light draught. Admiral Bouët sailed from Cherbourg July 23d with six iron clads and one dispatch boat, and he was promised that there should speedily follow six ironclads, five cruisers, Monitor Rochambeau and Ram Taureau. He was ordered to blockade the German fleet in the Jahde and on the advent of the reinforcement to leave one division of his fleet at that point and cruise in the Baltic; further it is even said that his orders forbade at that time an attack on an open town. The fleet was poorly equipped and even Danish charts were missing, rendering it almost impossible for him to get within useful distance of the coast where the lights had all been extinguished. On the arrival of Admiral Fourichon with seven ironclads, he assumed the blockade of the Jahde, leaving Bouët free to act. Bouët's fleet was composed of only heavy draught vessels unfit for inshore work owing to their draught. About August 20th a German officer under a flag of truce delivered a communication from General Falkenstein inviting the Admiral to respect private property at sea, and this officer doubtless under instruction, added that the squadron ought not to be ignorant of the victories of the Prussian armies in France, and that it was in the interest of the Admiral to agree to the demands of Falkenstein, as a refusal could not but prompt reprisals and increase war indemnity. The reply was simply, blockade and capture of merchant ships was authorized by the treaty of 1856, which Prussia had signed.

On September 5th Bouët learned of the fall of Sedan and later received instruction to inflict all damage he could. He again returned toward Colberg intent to attack, but for five days there blew such a gale, that he could not leave his anchorage off Arkona. On September 13th he started for Colberg, but a storm sprung up again and the fleet headed for Kioge Bay. From this port he ordered his fleet again to proceed to Colberg, notwithstanding he knew at that time, the blockading squadron had withdrawn from the Jahde and

the German fleet was free to act against him. Bouët's fleet were overtaken again by a storm and returned without effecting anything. It does not seem that Bouët would have taken this risk, if risk it be regarded, after knowing of the fall of Sedan and the consequent loss of all hope of success against Germany. It would therefore seem that the reason for the failure to attack Colberg should be sought elsewhere and not be laid to the presence of a flanking fleet, and doubtless the cause for this inaction may be found in the fact that Germany had secured such a footing on French territory, as to exact reprisals if her coast towns were bombarded, and secondly to the loss of morale on the part of the French and the almost entire hopelessness of effecting any real diversion in favor of France, and last of all to the withdrawal of the sailors to man the fortifications of Paris.

Whilst upon the subject of the French fleets in the Baltic and North sea, I wish to point out one fact as an argument against the claimed power to refit in an open roadstead. The French found it so difficult, that the fleet was divided into two squadrons and alternately returned to Cherbourg for refitting, etc.

Certainly in 1854 the allied fleet after the Russian vessels returned into Cronstadt proceeded to attack and capture the Russian casemated works at Bornasund, and again in 1866 the Italians made an attack upon the Island of Lissa in the Adriatic about thirty miles from Spalato; the island contains two ports, San Giorgio and Comisa.

The Italian fleet under Admiral Persano consisted of 28 vessels, among which eleven ironclads, left Ancona on the 16th July 1866. On the 18th of July three ironclads bombarded Comisa unsuccessfully, and the attempted landing could not be executed on account of the heavy surf. The rest of the fleet bombarded San Giorgio, succeeded in blowing up two magazines and silencing two Austrian batteries.

On the next day several Italian vessels entered the harbor and fired upon the inner batteries, but were severely handled by the Austrians. Average range from about 400 to 800 yards.

The Austrian fleet, 7 ironclads and 14 wooden vessels under Admiral Tegethoff was cruising off the peninsula of Istria. Flagship at Fasano, about 50 miles north of Lissa. Admiral Tegethoff having

received news of the attack of Lissa by the Italians, weighed anchor about noon July 19th and arrived off Lissa on the morning of the 20th.

These cases all come under the head of an attack by a flanking fleet well within the distance, which, it has been claimed, would give immunity from attack.

The defence of the harbors should be divided into two heads, viz. Active and Passive.

Under active we should class such war ships, harbor defence vessels, torpedo boats, etc., as may be furnished by the Navy. These harbor defence vessels need not have great speed and should be of such a draught as to enable them, if too closely pressed, to run across shoal places where the more powerful ships of the attacker cannot pursue them.

But we need not worry our heads over the subject of the character or the type of the vessels, that will constitute the defence. For at the best we will have to take what we can get, and there is little probability of our ever being consulted as to what we would like to have in this line.

Under Passive Defence we have:

1st, Guns.

2d, Submarine Mines and obstructions.

3d, Torpedoes.

4th, Water defence, that is such launches, tugboats, etc., as may be temporarily armed and used for service in connection with mine fields.

5th, Electric lights.

and to these should be added necessary signal stations, submarine microphones, etc.

Taking up the various heads in the passive defence, we find first in importance guns, and here this term is used advisedly instead of fort, for the fort should simply give the requisite cover for guns and mountings, and their position should in every case depend upon the proper position of the gun, which they are intended to cover. We might as well make here a division of the guns into three classes, primary, secondary and tertiary. The primary embracing all guns

of over 6 inches, or howitzers of over 8 inches and intended for direct or curved fire on armored or other parts of enemy's ships. Secondary consisting of lighter guns, rapid fire and others on permanent mountings intended to keep up a rapid shell fire on unarmored or lightly armored portions of ships and to assist in repelling landings and boat attacks and in some cases to have command of the mine fields. Tertiary, sometimes called movable, consisting of siege, field, rapid fire and machine guns and mortars mounted on travelling carriages; sometimes employed in emplacements within the works to increase shell fire and to assist secondary armament; generally however, placed outside the fort in selected positions, mortars placed in concealed batteries for the purpose of employing high angle fire at ships decks, etc.

With the increase of range of attack and defence, and the great diversity in draught, armor, armament and general capabilities of modern war vessels there has come increased difficulty in siting coast guns. The chart must be studied carefully and it is more than ever necessary for the officer charged with the defence of the work to be able to look at the question from the purely naval point of view.

Of course we seek to give the gun the fullest scope of the offensive power, and, also to have the protection of the gun and detachment as great as is compatible with the full scope and the never to be forgotten "reasonable economy." The protections may be divided into three groups: 1st, complete protection, only limited by the size of the port, to detachment and gun during loading. Examples: Shielded casemates with continuous iron fronts, Gruson battery, turrets, etc.

2d, Varying protection against direct fire, no bombproof overhead cover; detachments more or less protected from machine gun and shrapnel fire in various ways. Open battery with shields, open battery with earth embrasures, light cupolas, breech hoods with barbette guns, barbettes with turntable and horizontal splinter proof shield.

3d, Gun completely protected during loading, being lowered. Examples: Counterweight carriages, hydro-pneumatic carriages, etc.

Each head under these three groups has its advantages and dis-

advantages, which the limit of the lecture will not permit to enumerate. The disappearing principle will undoubtedly obtain great development as no other method of protection confers equal invisibility. Moreover a gun so mounted possesses the great advantage that further advances in the offensive powers of war ships are little likely to diminish the value of the protection.

I think I hear some one say that we are as little likely to be called upon to fortify a harbor with permanent works as to fight the ships of the active defence. But let us study nevertheless the various systems of harbor defences as at present devised at home and abroad as embodying the results of the combined thoughts of the specialists upon this branch of defence, and having mastered to as great an extent as possible the subject with the whys and wherefores, we will be able, if called upon to carry out a system of defence for some threatened but unfortified harbor. We will learn for instance the proper position for the primary armament; the value of heights and sites for same; but we must remember, that with an elevated site, there must be a circle without fire, owing to the carriages or superior slopes allowing but a small angle of depression. To find this, aim the piece with the maximum angle of depression and the point, where the shot strikes, will give a point for the circle of the dead angle of the piece and position. Again however, the ship cannot approach with probability of damaging within a certain distance of a high sited battery, owing to the lack of elevation permissible to her guns. Of course if she gets within minimum distance her guns will be useless against the elevated work. The resultant advantage will be with the ship or fort according as the circle of fire from the ship is interior or exterior to the circle which is within fire of the fort. To increase angle of depression by increasing degree of slope of the superior slope would introduce a weakness into the parapet, and the dead angle must be commanded by some auxiliary work.

Again, we will learn to employ rapid fire and machine guns in dispersed emplacements well separated from those of the heavy guns, rendering their armament almost invisible at moderate ranges and being thus protected. they should find little difficulty of keeping down

the fire of like guns on shipboard, as well as searching the unarmored portions of vessels.

Where positions are available, rapid fire guns will be placed on high sites to search decks, etc., and on lower sites to get the full value of a low trajectory to repel torpedo boats and others operating to remove mines or obstructions.

In regard to the mortar batteries you find on the plan studied that they occupy a certain position, and a close inspection will always merely disclose the fact, that from their position, they will command a portion of the channel where the war ships must come bow on towards them, thus presenting the best target, for under ordinary circumstances the deviation of the projectiles of the rifled mortar is greater in the direction of the range than laterally. We will find that every effort is made in the direction of dispersion and concealment of guns, and many other points will present themselves, which a a little study will elucidate and render valuable. I shall have more to say on the subject of guns later on in the lecture, and will now pass to the next subdivision of passive defence, viz.

Submarine mines and obstructions, and as the whole function of these is, to delay the enemy's ships under fire, their location will depend primarily upon the site chosen for the guns.

The science of defensive torpedo warfare may be considered to consist of

1. The arrangement of the mines in positions such that it would not be possible for a hostile vessel, attempting to force a passage into a harbor, etc., defended by such means, to pass more than one line of them without coming within the destructive radius of some one or other of the remaining mines.*

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* The difficulty of obtaining the above effect lies in the fact, that the destructive radius of a submarine mine is considerably less than the distance that must be maintained between them in order to prevent injury by concussion to the cases, appliances, etc.

The destructive radius of a submarine mine is found by the formula

$$R = \sqrt[3]{32.\ C}$$

in which R is the destructive radius in feet of a mine moored at its most effective depth and C is the charge (gun cotton) in pounds.

General Abbot concludes from his experiments that an instantaneous mean pressure of 6500 pounds per square inch would give a fatal blow to the double bottom of a modern armor-clad: he developed a formula which gives this blow with blasting gelatine at the following distances under water.

2. The combined arrangement of submarine mines with forts and batteries in such a manner, that every one of the former shall be well covered by the guns of the latter, and also that it would be impossible for an enemy's ship to get within effective range of the forts or batteries without moving over ground where mines are laid. Now in the case of a charge of 500 pounds of guncotton, the R would be about 24 feet, which in so far as actual destruction of the ship is concerned, may be taken as correct, but if injuries to a vessels engines, boilers, etc., be also taken into consideration and as the vessel would most probably be under way on such an occasion, this would be a very vital and important consideration, and R would under these circumstances be more than doubled. Now the necessary interval between such mines according to torpedo authorities is equal to 10 R and should certainly not be less than 8 R, which in this case would give about 200 feet; assuming the radius of destruction to be 50 feet, it will be seen that there would be under these conditions a clear undefended space of about 100 feet between each couple of 500 pound mines in the same line.

Submarine mines are generally divided into two separate classes, viz:

1. Mechanical mines fired by contact.
2. Electrical mines fired by judgment.

Experience hitherto gained with regard to the employment of mechanical mines for coast defence in actual warfare show that they will be exceedingly valuable in the following positions:

At	5 feet	. . . .	4 pounds
"	10 "	. . . .	17 "
"	20 "	. . . .	67 "
"	30 "	. . . .	160 "
"	40 "	. . . .	311 "

Horizontal destructive radius

100 pounds	dynamite No. 1	. . . .	16′.3
100 "	gunpowder	. . . .	3′.3
500 "	dynamite	. . . .	35′.0
500 "	gunpowder	. . . .	19′.5

An Italian experiment against treble bottomed caisson (facsimile of ships bottoms) witn 75 pounds guncotton broke two of the bottoms although the pressure should have been according to formula 300,000 pounds per square inch.

Experiments in England have shown that 500 pounds of guncotton at forty feet below any ship will sink her, and at a horizontal distance of 100 feet damage to the interior pipes and machinery is to be expected.

1. In combination with booms or other obstructions placed in defence of narrow channels, which are intended to be completely blocked up.

2. In shallow water on the flanks of electrical mines.

3. In protecting unfrequented bays, channels, etc., and a long line of sea coast, which may be otherwise entirely unprotected.

Obstructions.—Just as the mines themselves form a grand obstruction to the passage of large vessels, thereby greatly assisting the defence by the landworks, so smaller obstructions can be usefully employed to impede or prevent the passage of small boats, whose aim may be the attack of the mines.

Floating nets can be used, and if small steamers get among them, the propellers are often fouled and the boats become temporary helpless, so that they may be destroyed by a well directed fire from rapid fire and other guns. Nets however are easily seen and easily sunk.

Booms well made are probably the most effective passive obstruction against the passage of boats. They should always be formed of a double line of balks, at such distance apart, that a boat which succeeds in jumping or passing over the front line is brought up by the second. The two lines should be frequently connected by cross beams, the whole presenting the appearance of a large floating ladder. Wire ropes or chains should run along each line and be connected to the main anchors at each end of the boom. The French have lately brought in use during their naval manœuvres a boom constructed of wrought iron cylinders about 20 cm. long and connected by wire cable.

I would also make use of scows with water tight decks and loaded with stone, having an arrangement of valves for sinking, and on deck an arrangement for attaching a pipe reaching above the surface of the water. These could be towed at the last moment to the channel to be obstructed, the valves opened and the scows sunk. The danger once passed, we have but to send down a diver to attach the stand pipe, connect with the force pump, pump the water out and the scows will rise to the surface.

DESIGNS FOR MINE DEFENCES.

The designs for mine defences are more intimately connected with fortifications, than most people suppose. The positions of the fort and batteries, of the mines and cables, of the electric lights, of the firing and observing stations, in fact everything connected with the defensive works should form one harmonious whole.

As no two harbors are alike, so no two arrangements of fortifications or of mine defence will be the same, but the same principles apply to all, and they do not differ greatly from the broad ideas that should underlie the preparation of every defensive position. But mining differs from fortification in one important particular.

The value of sea mining is greatly enhanced, when the positions, or even the approximate positions, of the mines are unknown to the enemy. Not concealment of the efficiency of the apparatus employed, or how employed, but secrecy as to the position of the mines. Every artifice that may be thought of should be used, to attain this end; buoys, otherwise useless, should be placed to mislead the enemy, bogus mining operations should be carried on for the benefit of his spies, false reports concerning the mine field should be spread, and some of the mines, especially those in advanced positions should be laid at night.

THE ATTACK AND DEFENCE OF MINED WATERS.

The defence of mined waters must usually be effected by a powerful artillery fire, but the guns must be of the proper quality for their targets.

The costly modern forts and batteries are or will be provided with heavy armor piercing guns, but an attack on mined waters will of necessity be made by small craft, and it is therefore not desirable to throw away the expensive heavy projectiles upon them. Also rapid fire will be required, the guns to be selected therefore should be rapid fire and machine guns, such as Hotchkiss R. F. guns from 1 to 6 pounders, Hotchkiss revolving cannon and Nordenfeldt or other torpedo guns. These guns should be so placed on shore as not to be inconvenienced by the smoke from guns of heavy calibre, and should also be mounted in such a way as to be under cover

until the time they are required. The powder used ought to be smokeless.

It also will often be necessary to meet boat attacks with boats, especially if the mined waters are some distance from the shore. In such a case rapid fire guns should be mounted on a number of small steamers, such as steam yachts, tugs, etc., to be found in every harbor; a number of these guns should therefore be kept in store for their armament.

ATTACKING MINE FIELDS.

Creeping for cables and destroying them by means of explosive grapnels fired by electricity is a good and reliable method of attack, and since it can be undertaken by small row boats the element of surprise will assist the operation on dark nights, when boats cannot readily be discovered. To throw difficulties in the way of such an operation the waters in front of the mined areas should be liberally sown with pieces of old cable, lengths of chains, etc., and these bottom obstructions become more efficient, if they are connected with small sinkers here and there and with submerged buoys between the sinkers, the loops of dummy cables or chains thus formed near the bottom, being designed to catch the grapnels.

Sweeping for mines by boats in pairs, with drift ropes or nets between them, is a most difficult operation to carry out at night and it would of course be impossible to carry it out successfully by day under a hostile fire.

Attack by countermining is advocated by many and its efficiency is fully believed in by a number of naval officers, whose opinion on such a subject should certainly carry weight. Nevertheless it cannot be denied that the methods usually adopted in Europe are crude. In the United States the dynamite gun perfected by Captain Zalinski promises to give better results.

Coming to the 3d head viz. Torpedoes, we will take but a passing glance, as up to the present writing I know of no post which has been furnished with a single torpedo. We may mention the Whitehead, the Howell, the Lay, the Ericson, the Berdan, Sims-Edison, Nordenfeldt, the Patrick, the Lay-Patrick and Brennan. The Berdan is propelled by the gas from burning rocket composition; the

Lay and Patrick by compressed carbonic acid gas; the Ericson by compressed air; the sims-Edison by electricity locatéd at base; the Nordenfeldt by electricity carried in the torpedo.

Each has its advocates and whilst I would not say one word to deter you from personal investigation and study of them all, it seems to me that we of the sea coast artillery have greater hope for a solution of the difficulty in the pneumatic gun, recently tried at Sandy Hook, with results, if press reports are to be relied upon, the most encouraging.

Call the gun as you may, the projectile is simply an aërial torpedo with the sphere of action extended to enable it to act after entering the water. And being such we may enumerate some of its advantages. Not liable to be stopped by boom or netting. Greater speed than any automobile torpedo. Rapidity of discharge.

No long life artery of wire exposed to injury, Good practice can be had when the object attacked is enveloped in smoke, if only as much as a mast be exposed. In thick weather, fog or darkness, if some object be visible, we have every advantage over an automobile torpedo which must be kept and guided during the whole run. There should be little difficulty in locating and directing the fire of these guns, so that their projectiles shall not damage the mine defences; but mobile torpedoes cannot always be employed in waters mined with electro-contact and automatic arrangements, which are near the surface at low water, especially where there is considerable tidal range.

But perfect this branch as you may, submarine mines should never be replaced by pneumatic guns or mobile torpedoes, for they do not possess the blocking effect of hidden and unknown mines.

4. *Water defence.*—I have touched upon this subject, whilst speaking of submarine mines and have only to add, that the extent to which the defence will be carried, depends entirely upon the number of suitable craft available and guns for the same; and the importance should not be overlooked in view of the vast increase of range and penetration of the projectiles of rapid-fire guns, which with their mounts are of a weight, well within the carrying capacity of good sized tugs.

Take for instance the latest pattern of the Hotchkiss 6 pounder rapid-fire gun of 50 calibers with front shield and slanting top, diameter of bore between grooves 2″.282; weight of gun 1144 pounds; total weight of gun mounted with pedestal, shield and accessories 3047 pounds; initial velocity 2625 feet; penetration in wrought iron at muzzle 7″.9, at 1000 yards remaining velocity 1961 feet; perforation 5″ wrought iron.

5. *Electric lights.*—The importance of this accessory to the defence is so well recognized as to need only simple mention. It has been proposed that when hostile boats come to close quarters the expensive lanterns may be lowered, and an arrangement raised whereby the ray of the light may be reflected in any desired direction by a cheap plane mirror, that can be easily replaced when broken. During the French naval manœuvres in 1892, on more than one occasion the electric search lights mounted on shore were so handled, that some of the adjacent forts could not train their guns on the hostile ships with accuracy, although the ships could be plainly seen from other batteries.

This in no way subtracts from the value of the search light, but suggests the importance of long continued practice in such work under varying conditions, such as for instance the smoke of our own guns or those of the enemy; rays of light thrown by an enemy's ship either across our ray or directly on the guns themselves, etc.

Having touched thus lightly upon the various heads of coast defence I would now call your attention to certain facts, which must be studied in order that we may intelligently perform the duties, which will undoubledly devolve upon us in case of war.

It seems to me that just here I might give an explanation of the terms "Rapid fire and Machine guns" with a few data as to range, etc.

Rapid-fire guns.—The term rapid fire gun is now applied to all calibres of single-shot guns, which use fixed ammunition, that is the projectile, charge and primer are combined ready for use, and but one single operation is necessary in loading.

The breech mechanism is also so constructed, that it operates by lever quickly, and this combined with quick training and quick loading allows several shots to be fired in one minute, the number de-

pending upon the size of the piece and the weight of ammunition to be handled. They form the principal part of what is known as the secondary armament.

Machine guns.—A machine gun may be defined as consisting of any number of breech-loading rifled barrels, grouped around an axis or arranged in a horizontal line, which are loaded and fired in continuous succession, or by volley, by the action of suitable machinery at the breech, the power being applied by crank and gearing, or by levers, and using fixed ammunition, the empty cartridge shells being automatically ejected. There are numerous types in use in various countries; among them may be named the Gatling, Nordenfeldt, Hotchkiss revolving cannon, Lowell battery gun and Gardner gun. The Gatling, Lowell battery, Nordenfeldt and Gardner guns use small-arms ammunition, while the Hotchkiss and the Nordenfeldt Torpedo guns use projectiles of one-half pound and upward.

PERFORATION OF RAPID FIRE GUNS.

Krupp's 15 cm. (5″.9), 40 calibers long, at muzzle,	in wrought iron.
weight of charge 29 lbs., projectile 88 lbs,	22½ inches.
Canet 15 cm. 40 calibers long, at muzzle,	in wrought iron.
weight of charge 31.2 lbs., projectile 88 lbs.,	21.6 inches.
Canet 12 cm. 45 calibers long, at muzzle,	in wrought iron.
weight of charge 12 lbs., projectile 46 lbs.,	14.7 inches.
weight of charge 10 lbs., projectile 46 lbs.,	16.3 inches.
Krupp's 10.5 cm. 35 calibers long, at muzzle,	in wrought iron.
weight of charge 8.8 lbs., projectile 39.68 lbs.,	9.5 inches.
weight of charge 5.23 lbs., projectile 35.27 lbs.,	10.43 in.
weight of charge 5.95 lbs., projectile 26.45 lbs.,	11.08 in.
Canet 10 cm. 48 calibers long, at muzzle,	in wrought iron.
weight of charge 7.74 lbs., projectile 28.66 lbs.,	13.6 inches.
Hotchkiss 6-pounder, 50 calibers long,	
weight of charge 1.98 lbs., projectile 6 lbs., at muzzle	7.9 in.
at 1000 yds.	5 in.

Hotchkiss 1 lb. penetrates torpedo boat up to 3100 yards.
Hotchkiss 3 lb. at 45 yards 4¾ inches steel.

at 380-600 yards	3 1/8 inches steel.
at 600-1200 yards	2 3/8 iuches steel.
at above 1200 yards	5/8 inch steel.

The following rapidity of fire is claimed:

Armstrong	6 in.,	2 aimed or	7 unaimed shots.
Krupp	5.9 in.,	3 aimed or	7 unaimed shots.
Canet	5.9 in.,	4 aimed or	8 unaimed shots.
Schneider	5.9 in.,	4 aimed or	8 unaimed shots.
Hotchkiss	33 pdr. 6-8 aimed.		
Hotchkiss	55 pdr. 6-8 aimed or 10-12 unaimed shots.		

Armstrong claims three shots from 8-in. R.F. Gun in 28 seconds.

Our Board on Ordnance and Fortification desire to provide a rapid-fire gun of about 4″.72 for defence of mine fields. They have also purchased a Hotchkiss, Armstrong and Canet gun, and been furnished a Skoda gun. The test awaits the arrival of the Canet, now on its way to this country. They are also testing for flank defences and shorter range protection of mine-fields, etc., six-pdr. R. F. G. Driggs–Schroder, Hotchkiss Spensel, Maxim, Nordenfeldt and Seabury. The trial of these has been made but the report as yet not completed. These guns will all use smokeless powder.

With this slight digression we will return to our theme. A defence will in all cases be with a view to the possible mode of attack; we should therefore carefully study the method of attack, uninfluenced by the object of the attack, remembering that the most intense fire, at every phase of an engagement, should be directed on that part of the attack, whose action if successful, would imperil the defence.

1. A fleet may attack with a view to occupying temporarily the water area commanded by it while a force is being landed, or again, it may be for permanent occupation for use—a harbor as a naval base or as a base of supplies for a naval force. It may be urged that an army would be landed on some undefended part of the coast, but in the absence of some occupied post the supplying of the army would be most precarious.

2. An attack may be made with a view of destroying shipping,

dock yards, naval depôts and sea-going supplies covered by the guns of the sea-coast works.

3. The attack may be made for moral effect, or to detract attention from other posts of the coast line.

Again the method of attack will vary accordingly as the works defend a roadstead open to the sea, or a channel giving access to a harbor or mouth of a river. Should the object of the attack be to occupy defended waters, the guns bearing on these waters must first be silenced, and if occupation is to be permanent, the forts must be reduced or rendered untenable. This is to be accomplished either by bombardment from the ships alone, or more usually by a combined attack from land and water. When the defended water is an open roadstead, whatever the object with which it is attacked, that attack must take the form of a bombardment, since the object desired will have to be accomplished in water covered by the fire of the forts. In the case of a channel leading to a harbor or the mouth of a river, if the object were to seize or destroy material or shipping beyond, it would not always be necessary to bombard the forts. Armored vessels if able to pass the forts at speed might well afford to neglect their fire, and it is to prevent this action on their part that channels are protected by mines, booms and other obstructions, so that they may be delayed under the effective fire from shore guns. The obstructions would first have to be dealt with by the enemy, and when a channel through them were cleared, the ships would probably attempt to run past without returning the fire of the forts from their primary batteries at least, but using perhaps their rapid fire and machine guns to render fire less accurate from the forts, or conditions being favorable, they may cover themselves with their own smoke. These tactics though would presuppose that the forts once passed, the ships could reach a safe position out of fire of the guns on shore. Otherwise a ship might run past the fort at the entrance, only to find herself engaged by minor defences, and would run the risk if worsted by them, to repass the fort with her fighting efficiency impaired. Whereas if she was able to get to safe waters beyond the fort, she would probably rely on getting out again with as little damage as she received in getting in. Thus we have two

forms of attack by ships against which we must provide; bombardment and running past, or the two may be used in combination.

I have before said it is claimed that there will be no bombardment of forts by ships, but it behooves us of the heavy artillery to study the methods by which we hope to successfully resist such an attack, should it occur, and not rest supremely on our safety from attack. The better prepared we are the less likely the attack.

Should a fleet decide upon an attack, the ships will probably be brought to as close a range as possible, for only in this way can it hope to obtain good results, and as bombardment presupposes a superiority of guns and consequently a large number of ships, it will probably have to anchor, as there would be little room to manœuvre at close range.

Every effort should be made to open an effective fire at the fleet whilst advancing to take up the position, as it is, during this period, that the forts will have the advantage over the ships, and by a well directed fire, we may so derange the enemy's plans as to at least prevent certain of his ships from reaching their assigned positions; besides which it is necessary to draw the fire of the ships as early as possible so as to exhaust their ammunition, the supply of which must be necessarily limited, and moreover the strain on the crew is greater under fire, and we must remember that with all the vast improvement in guns, armor, &c., man, who must direct, remains the same, and that in the measure in which we exhaust his vital forces. just in that measure do we impair his usefulness for any work he may have to perform.

Generally speaking it would seem better to concentrate the fire on a few ships, preferably those at shortest range, or which were causing the greatest annoyance with the greater number of the guns; distributing the fire of the others so as to cause a feeling of insecurity and consequent loss of accuracy. It would be better whilst the fleet is in motion to totally disable one ship than to slightly damage several. A large part of the secondary and tertiary armament should be employed to keep down the fire of like guns aboard ship, which would doubtless be directed in such a way as to prevent the guns of the fort being worked. High angle fire from mortars when

ships are passing points of known range, could also be used with effect, especially if the number of mortars be large.

Should the fleet only wish to bombard the shore works with a view to produce moral effect or to divert attention from some other operation, which is being simultaneously attempted, such as landing troops, removing mines or other obstructions, or the attempt of vessels to force a passage, the ships so engaged will, so as to minimize the risk of being crippled, keep on the move. The forts should be able, in view of the fact that accurate fire can now be directed on many objects, to compel such vessels to keep at such a range, that their own fire cannot be very inaccurate. Just here we may note that the amount of risk which attacking ships would be willing to expose themselves, would depend in a great measure on the distance of their base, or the probability or otherwise of their being attacked on the route to refit by hostile vessels. The farther the base and the greater the liability to such attack, the less likely they are to run serious risks of being crippled in attacking coast defences.

The bombardment by ships in motion, we have said, will be usually resorted to for the purpose of covering some other operation, while therefore replying to it sufficiently to keep the vessels at a distance and to prevent the attack from becoming dangerous, our main power should be directed to defeating the ulterior object of the enemy. Should this from development be shown to be the landing of a force, we should immediately make arrangements to keep up as heavy a shell and shrapnel fire as possible on the landing places and their approaches, and for this purpose a considerable part of the secondary armament should be kept in reserve, as also the tertiary.

These guns not to open fire until boats carrying landing parties are within effective shrapnel range, so as to as long as possible mask their positions. As boats approach landing fire from ships must slacken, and then the heaviest fire possible should be opened from all available guns on the boats. Ranges from the forts and positions of the movable armaments to the landing places should be previously obtained; infantry if available, and machine guns would also be used. The conditions necessary for a successful attack by landing parties are that the garrison should be taken by surprise, or that the

attacking force should be superior in numbers, and the defenders shaken by the preliminary fire of the ships. To obviate this, defenders should not unnecessarily show their positions, and the enemy's ships should be kept at such a position as will ensure their fire being ineffective.

The destruction of mines and other obstructions in the channel would usually be attempted by boats under cover of darkness, fog or the smoke of their ship's guns. In the first case this attack would be resisted by the boats of the defence, but these if unsuccessful should draw off behind obstructions leaving further defence to the artillery. Rapid fire and machine guns are best, but they would be assisted in most cases by the tertiary or movable armament. Should attack take place by daylight or if electric lights be available, the enemy's boats would be attacked by the ordinary methods, but if by reason of fogs, etc., the boats cannot be seen, other means must be adopted. For this purpose the mine field or obstructed channel is divided into zones, and to each zone are allotted certain guns, the range and training to the center of the position and the length of fuze are ascertained and noted on a range board on side of carriage. Elevation giving degrees and minutes, taking into account height above water, must be calculated. Training must be arranged when there are no arcs, by nailing battens or painting lines on platform and against trucks or wheels, and the trails can be brought to at each range, so that the gun will point in the required direction, or backlaying may be resorted to. Great accuracy in laying is not important. A previously agreed upon signal would show when the area to be defended is clear of the defending boats, when a rapid fire of shrapnel and case shots from guns in case shot range would be opened. Just on this point I question very strongly if it would not be better to limit the defense of the mine field to the artillery on shore. For in this case there would be no chance of the defender's and assailant's boats being mistaken for each other, or masked the one by the other, but the simple fact of the presence of a boat in the mine field, except when special notice was given to the officer charged with the defence, would be a signal for all guns to open fire upon it.

Should an attempt be made to force the passage of a channel under cover of a bombardment or not, every effort should be made to so disable the leading vessel or vessels, as to cause a check in the advance of a squadron and so detain them under fire. A striking instance of this occured in Mobile Bay in 1861. The deep water channel was partially blocked by torpedoes, so that vessels would have to pass close to Fort Morgan, which defended the entrance to the bay. When opposite the fort, the leading monitor, the *Tecumseh*, bearing too much to her left was sunk by a torpedo, and this change in her course also caused the leading wooden vessel to come on to the line of the torpedoes; on perceiving which she stopped, thus throwing the whole column into confusion and checking the advance under the guns of the fort. The check lasted about ten minutes, until the flagship taking the lead, passed in safety over the torpedoes, and the whole column passed beyond the guns of the fort. The loss was heavy during the check, and but for the intrepidity of Admiral Farragut the attempt would probably have ended in disaster. In resisting such an attack it would seem that the best policy would be to attack the leading ship or ships with every gun that can bear on them, and that the object should be to attack the vitals of the ship rather than to inflict losses upon the crew or damage to the armament. Should the shore works be successful in checking the advance, the fire should then be distributed on the fleet with the view of doing as much damage to armament, and inflicting as heavy losses as possible to the crew, during the time they remain under fire of the forts; any vessel absolutely stopped might safely be dealt with by the high angle guns or mortars.

The question at what ship to fire having been decided, the next consideration is what damage shall we attempt to inflict on her, or in other words, what part of the ship shall we attempt to hit and with what projectiles. In order to decide the answer to this question some knowledge of the construction of warships is necessary; and I cannot too strongly urge upon one and all of you the study of this object, which is of most vital importance to those to whom must be intrusted the defence of the sea-coast. It is not necessary to go

over the plan of every ship, though the greater the knowledge the greater the value, but in the start take certain vessels as typical of their class in each country; having studied thoroughly the representation of the type upon the lines of armor and armament, disposition of same, ammunition lifts, stability as affected by damages in certain positions, then we will have only to note slight modifications in sister vessels. I have prepared drawings, approximately correct, of the *Royal Sovereign* (English) and *Jauréguiberry* (French) and would call your attention to the same.

Stability.—The word stability is usually used by naval architects to express not only the existence of a righting tendency in a ship inclined in still water, but also the amount of such tendency, *i. e.*, the righting moment of the ship. The displacement of ships being always expressed in tons, their righting moments are naturally expressed in ton-feet.

The modern naval vessel must be constructed with a view of providing the best possible gun platform. Her stability and rolling qualities must be adapted to this end as far as consistent with her uses as a ship.

These views have given a special value to determinations of the stability of ships. The heeling test has been applied to many of our naval vessels to determine the location of the centre of gravity, which in connection with the metacenter controls not only the stability, but what is of equal importance, has a great effect upon the rolling period. A ship of high stability, one which might be considered of exceptional safety, is liable to be so bad a roller as to be

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A foot-ton is the work done in raising the weight of a ton through the vertical height of one foot.

A ton-foot is the moment exerted by the weight of a ton acting with the horizontal leverage of one foot.

A ship floating at rest in still water and acted upon only by her own weight and the buoyancy of water, must

1st. Displace a weight of water equal to her own weight.

2nd. Have the centre of gravity vertically above the centre of gravity of the water displaced, usually called the centre of buoyancy.

When the above conditions hold, the weight of the ship, which may be regarded as acting downward through the centre of gravity, is exactly balanced by the buoyancy of the water, which may be regarded as acting upward through the centre of buoyancy.

uncomfortable and a very poor gun platform. Initial stability, as brought about by a flat light-draught model with high centre of gravity, makes a ship very easy in her motions. But too high a center of gravity gives a dangerously low critical angle, or angle of vanishing stability as it is termed, in other words the angle at which the ship would capzise becomes too small. The naval constructor therefore stands between two fires. If he makes his heavily weighted ship, with most of her side armor, protective deck and part of her coal bunkers perhaps above the water line, of high initial stability and easy rolling qualities, she may be a good gun platform but a very unsafe one. The filling of a single compartment with water might be sufficient to overturn her.

Then again if the center of gravity is too much depressed, her violent motions in a seaway would render gun practice from her decks very uncertain.

ARMOR.

ARMOR AS APPLIED TO SHIPS.

Wrought-iron.

Steel.

Compound.

Wrought-iron yields locally, is punched or perforated, a clear hole being made through it; is generally capable of resisting a subsequent blow as stoutly as it resisted the first. Useless to attack this species of armor unless the power of the gun is sufficient to drive projectile through armor. Measure of power to penetrate is given by the rule, that to penetrate their own diameter in wrought-iron a shot must strike with a velocity of 1000 f. s., and the penetration with greater or less velocity will be proportional. The rule of course is based upon the presumption that the shot strikes the plate in a line normal to the surface. When it strikes it at an angle, the thickness of plate perforated is in proportion to the sine of the angle at which it strikes, thus a shot striking at 60° to the surface will penetrate roughly $\frac{6}{7}$ of the thickness it would penetrate at normal. Below 50°

shot will glance from wrought-iron, and from hard armor it will glance at below 65°.

Steel faced and steel armor, usually called hard armor, yields by fracture, the plate cracking radially from point of impact, these cracks extending through thickness of metal in the case of steel (soft steel however has been sometimes perforated, behaving like wrought iron). These armors not admitting of perforation as a rule can only be destroyed by repeated blows, striking and stripping off the plates. Rule for penetrating compound armor by steel shot $\frac{4}{5}$ of caliber of shot for every thousand feet seconds of striking velocity. In case of iron armor, the shot penetrating through it damages the plate at point of impact, and will probably do serious damage to whatever is behind it, whilst with hard armor no such damage will be done, but the plate will be less able to resist a subsequent blow.

Horizontal armor may be attacked by direct fire, provided the angle of descent is over 10° and the striking velocity sufficient, the penetration at this angle being about one-fourth of that obtainable with an equal velocity by a direct hit on vertical armor. The angle of descent depends on range and height of site of gun. Tables must be worked out in each group according to height above water. It must be borne in mind that the armored deck is usually about the level of the water, and there are generally one or more decks above this, so that the shot will have to pass through obstructions, thus losing force before reaching armored deck.

Common shell can be used against thin iron armor, the perforation being equal to one-half diameter for 1000 f.s. velocity; but backing would greatly impede further course of fragments, in this case shell should be plugged. The resistance offered by armor approaching thickness which the shell can penetrate, would check velocity so much that a fuse would act before penetration were complete.

Regarding attack of armored decks by high angle fire, the same rule for finding the penetration applies as in other cases. Steel shot are best for this purpose, as they are less liable to break up when striking an object not truly point first. We must remember that shots are liable to be deflected by upper works of the vessel before reaching armored deck, and so may strike in any position.

The attack of armored ships or unarmored portions of protected ships, would be carried out with common shell when damage to vessel and armament is desired, and shrapnels when losses to crew are sought. Common shells plugged have been found to explode when passing through the armor or the sides of unarmored war ships, and it has been proposed to plug them always; but to do this would exempt any object on deck from destruction, which while offering sufficient resistance to set in action the fuze, would probably not explode a plugged shell. It would seem best then to use common shell with percussion fuses except at short ranges, when we can be sure of hitting the sides and in this case plug them. Open boats should be attacked by time shrapnels, or case shot when within effective range of that projectile. Torpedo boats will probably be dealt with by rapid fire guns of lighter nature.

Summing up we have to make our choice between attacking the armored or unarmored parts of the ship, and as regards the projectiles, armor piercing shot or common shell. Now from consideration of the distribution of armor in foreign ships, it is evident that most of them can be heavily damaged by attacking the unarmored portions. Besides the armament and crew there is a great deal of subsidiary machinery, communications, &c., which is unprotected on all ships, so that every shell bursting between decks is sure to more or less cripple the fighting efficiency of the ship, and in proportion to her distance from her base, any ship would be unable to endure more than a certain loss in guns, men and material. From the nature of armor we know that unless we can more than penetrate it, or unless we can get several hits successively or simultaneously on hard armor, we cannot hope to inflict much damage upon the vitals of the ship. Again the target offered by the armor is a difficult one, consisting as it usually does of a narrow belt, rarely more than 5 feet and in some cases 1′ 9″ above the water, and of one or more patches at different parts of the ship, whilst the unarmored portion offers a large target bearing a proportion of from 3 : 2 to 4 : 1 of the armored target in most vessels. On the whole it seems preferable to attack the unarmored portion at any rate with the greater part of the armament, while a few heavy guns may

attack the armor when well within their power, and at a range when close shooting may be relied upon. An exception to this would be in attacking the vitals of a ship leading a squadron attempting to force a passage, for the reason that the fire of the forts would have to be so much distributed, that unless by checking or stopping their progress, we can gain but little time in which to fire at them. As to the armament of a ship, her secondary battery and auxiliary armament would probably cause us most trouble, and should therefore be first attacked; primary guns in barbette may be rendered useless by the explosion of heavy common shell beneath the barbette. If there be a weak spot in the ship, as for instance the absence of armor in the hoist of a barbette ship, this weak point should be fired upon.

1. Fire should be opened at as long a range as possible with common shell and percussion fuse, unless armored deck is well within power of guns at that range; also use howitzer fire if vessels are at anchor or passing some point of channel, of which the range has previously been obtained.

2. When the range has been decreased to the point at which penetration of the armored deck may be reasonably expected, use armor piercing projectiles until further decrease of range causes angle of descent to fall below ten degrees. If no penetration can be attempted, use percussion common shells at the deck until this angle can be reached.

3. When armored deck can no longer be attacked by direct fire, use percussion common shell at unarmored parts of vessel; a part of secondary armament should employ percussion shrapnel at upper deck and at secondary battery, percussion or plugged.

4. When range is further decreased to a point where guns are more than a match for vertical armor of the ship, taking into account the inclination of her course to the line of fire, and at which (taking also into account the size of the armored target) there is a reasonable hope of hitting it, use armor piercing projectiles at that armor, for preference choosing the belt to fire at.

5. Attack of unarmored parts of the vessel by percussion common shells and plugged shrapnel should be continued simultaneously

with the attack of the armor, the latter task being alloted to a portion only of the primary armament. Common shell plugged may be used when there is little likelihood of missing side of ship.

6. Rapid fire and machine guns should be employed to keep down the fire of auxiliary armament on tops and upper deck, and at close range to fire at the ports and where the height of the site permits into barbettes.

7. At close ranges time shrapnel should be used to clear decks, and to prevent the working of the guns in barbette of stationary ships.

8. Against armored cruisers of the type of the *Dupuy-de-Lôme*, having completely armored hull or other lightly armored vessels, attack as above, except that when the range is such that penetration of her armor by common shells may be expected, use that projectile plugged against the armor.

A given number of shots penetrating soft armor will probably do an equal amount of damage, whether they strike successively or simultaneously. On the contrary, a ship protected by hard armor will be probably damaged much greater if these shots strike the armor simultaneously; explosion of several heavy shells between decks may be expected to produce much more disastrous effect, than would be caused by same number exploding singly. The racking effects on ships generally will be certainly greater if projectiles strike at same instant. For this reason guns generally will be fired in salvos; the only exception being when ships are laying off at long range and the action is likely to take a long time, or when at the commencement of an action a few trial shots are fired, to obtain necessary corrections. The groups may fire independently or successively. The former giving the greatest volume of fire in a given time, and the slowness of one group will not delay the other; generally chosen when using quadrant elevation and training arc. Successive group firing commencing with leeward group would be resorted to when using sights, to avoid interruption in the laying or of one group by the smoke of another. Rate of fire would be naturally slow and deliberate at the longest ranges, increasing in rapidity as the range decreases and the projectiles have more effect.

Whilst again ships forcing a passage past forts, the fire, as the approach the part of the channel where it is most effective, should be as rapid as possible, consistent with accuracy.

Before leaving the subject there are one or two points on which I would say a word. There is another protection, slight it is true, which comes into play in modern ships, viz: that derived from the coal placed in bunkers, so contrived as to give additional protection to some vital point. Roughly speaking, two feet of coal is equal to one inch of iron or steel, face not hardened. I have mentioned the rough rule for obtaining the penetration of wrought-iron; that to obtain the perforation in steel equivalent to a given perforation through iron, we have $1''$ steel $= 1\frac{1}{4}''$ iron. That is $4''$ steel $= 5''$ iron. Thus given $9''.4$ perforation through iron $9''.4 \times \frac{4}{5} = 7''.52$ steel, or given $5''.2$ steel $3''.2 \times \frac{5}{4} = 6''.5$ iron.

Finally whilst funnels appear tempting marks for light guns, but little can be accomplished by striking them above deck, for the boilers are placed low down in the hull and the funnel must be measured from the fire grates. Supposing the total length of funnel 50 feet, cut down to 30 feet. The diminished power of generating steam is in the proportion of $\sqrt{30}$ to $\sqrt{50}$ that is approximately 5.5 to 7.1. The rate of speed is nearly proportional to the cube root of the generating power, that is $\sqrt[3]{5.5}$ to $\sqrt[3]{7.1}$ or about 1763 to 1.920; in other words the ship would lose 1 knot in 12 by such an injury, though inconvenience would doubtless be felt from escape of smoke on deck.

RANGING.

When we come to consider the means by which we can ensure within certain limits that our projectile will hit the object fired at, we find there are three methods in use; two methods depending upon the availability of instruments,

1st. To find the range.

2nd. To find the position of the object.

While we would resort to the third only in the absence of all instrumental aid.

With the first and second I will not tarry, as the study of the instruments necessary to an intelligent use will give all the points necessary, but will speak of the third only.

We have no instrument to find the range, and the best way to make the method clear is to illustrate by an example. Let us suppose that an object is approaching us and is *not* at an estimated distance of 2000 yards. We first fire one shot with an elevation for 2000 yards, to make sure that the distance to the object has not been overestimated. For this shot an elevation should be selected so much shorter than that at which the ship is believed to be, as will allow plenty of time to load and lay the remainder of the guns. We may suppose the object advancing at the rate of four miles an hour, at this rate it will cover 200 yards in about one and one-half minute. We now fix 1800 yards as the elevation at which to fire our first shot. The burst of the shell or the splash of the projectile will show us whether this shot fell between us and the ship, or beyond. When ranging with percussion shell the object should be to get the shell to burst to windward, so that the drifting smoke may give a clear indication of the result of the shot, and sufficient deflection must therefore be given to carry the shell to windward flank. If the splash be between us and the ship we can judge whether it is well short or close up. We cannot estimate the exact amount it was short, but we can generally tell that it was a good deal or not much short. If not short or close up, we would have to take off another 200 yards elevation and lay again; but if well short the greater part of the guns which have been told off as salvo guns, are loaded and laid at an elevation somewhat shorter than that of the first shot, in this case 1750 yards. All the guns are kept laid on the ship, the ranging guns with an elevation of 1800 yards, the salvo guns with 1750 yards, and at intervals a shot is fired from one of the ranging guns; as long as these shots are observed to fall short, we know that the ship has not arrived at the 1800 yard range, but as soon as one is observed to hit or to fall over, we know that she has arrived at or come under that range, and making a short pause, a salvo is fired from the salvo guns; the ranging guns are loaded and laid at 1600 yards, the salvo guns at 1550 yards and the process repeated.

If the ship has been retreating instead of advancing the operation would have to be reversed. Usually two guns are told off for ranging. If the speed of the ship is greater, a larger difference must be made between the elevation of ranging and salvo guns, and also a larger difference between the successive predicted ranges. When several groups are being fought in this way, the leeward group would perform the ranging; in case of one gun the two leeward guns. The system would usually be employed with guns of the movable armament not supplied with depression range finders, but even guns of the primary armament must be fought by this method, if their position or range finding instruments are for any reason unavailable. Should the ship make a diagonal course with respect to the line of fire, deflection will be necessary to compensate for the transverse movement during the time of flight. A rough rule to find the number of minutes deflection necessary when no instrument or tables are available, is to multiply the supposed rate of the objects in miles per hour by five. In a diagonal course the distance between successive predicted ranges may be decreased, as also the difference between elevation of ranging and salvo guns.

An object in motion cannot remain at a constant range unless it moves in the arc of a circle, in such an unlikely case the range could be found as for a stationary target. In cases where the object fired at is stationary we could proceed as follows: All the guns of a group are used to find the range; the first shot from the leeward gun is fired at the estimated range, the second with so much added to or subtracted from it, as will cause its falling on the opposite side of the object; if successful in this the object is now included between the known ranges, this is called obtaining the "long bracket;"* the next shot is fired at the mean of the bracket, the next at the mean of the last elevation that gave a plus (+) and the last that gave a minus (—); the process is repeated until the object has been included between two elevations (ranges) which only differ by 50 yards, called the short bracket. "A verifying series" of usually four shots is then fired at the mean elevation of the short bracket, if the result be that half of the verifying shots go over and half under, the mean trajectory passes approximately through the water line of

* Bracket or fork (the latter being a literal translation of the German word "Gabel").

the object. If the object be a low one such as a boat, we could accept this as the correct range. If the object be a high one as the ends of a ship, we must raise the mean trajectory by adding 25 yds. elevation, anything over five feet should be looked at as a high target. If three-fourths of the verifying series are over, the mean trajectory passes above the water line, and we should keep at that range with a high target, but reduce by 25 yds. for a low one. If three-fourths are under, the mean trajectory is short of the object and must be increased. If the first three shots at a low target or first two at a high one are under the proportion is already wrong, and the verifying series should be continued at the increased range; if the first three are over at a low target the proportion again is wrong, and the series should be continued at the reduced range. In all ranging it is most important that all guns should invariably be laid on the same spot. In sea-coast gunnery this spot is defined to be the water line at the stem of the ship, or when the ship is in such a course that the stem is not visible, then at the water line at the stern. If it is desired to shift the trajectory to any other point of the object, this must be done by correction on the scales, and not by laying on different parts of the ship. When time shrapnel is used at the decks of ships at anchor, the elevation must be corrected to shift the trajectory on to the deck, and the height of burst judged from the level of deck. Apparent height in feet above deck must not exceed two-thirds number of hundreds of yards in the range.

STATIONARY OBJECT.

Better to have first shot short rather than over as giving a more easily observed result, especially in cases when the object would probably be obscured at intervals by its own smoke, but as our endeavor should be to always hit if possible, the first shot should not be fired at a range known to be less than the object. Make bold alterations for second shot; creeping up is very slow and wasteful of ammunition. Take no notice of the result of a round which was unsteady in its flight or the result of which was not properly observed, but repeat a shot at the same elevation in such cases. If a hit be obtained before the verifying series be reached, at once commence such a series at the elevation which gave the hit.